

WHAT IS CLAIMED IS:

1. An ESD dissipative ceramic composition formed by sintering a mixture comprising a base material and one or more resistivity modifiers for a sufficient time and at a sufficient temperature to achieve at least 99 percent of the theoretical density,

wherein the base material comprises a tetragonal zirconia polycrystal (TZP);

wherein the resistivity modifier comprises from about 5 vol.% to 60 vol.% of the base material and is selected from the group consisting of conductive and semiconductive materials or mixtures thereof;

and wherein the ESD dissipative ceramic composition has the following physical properties:

- (a) volume resistivity ranging from  $10^3$  -  $10^{11}$  Ohm-cm;
- (b) flexural strength of at least 500 MPa; and
- (c) voltage decay time of less than 500 ms.

2. The ESD dissipative ceramic composition of Claim 1, wherein the TZP comprises yttria stabilized TZP (Y-TZP) wherein the yttria is present at from about 2.5 to 4.5 mole percent.

3. The ESD dissipative ceramic composition of Claim 2, wherein the Y-TZP comprises 2.6 mole percent yttria.

4. The ESD dissipative ceramic composition of Claim 2, wherein the Y-TZP comprises 2.8 mole percent yttria.

5. The ESD dissipative ceramic composition of Claim 2, wherein the Y-TZP comprises 3 mole percent yttria.

6. The ESD dissipative ceramic composition of Claim 1, wherein the resistivity modifier comprises from about 10 vol.% to 50 vol.% of the base material.

7. The ESD dissipative ceramic composition of Claim 1, wherein the resistivity modifier comprises from about 20 vol.% to 40 vol.% of the base material.

8. The ESD dissipative ceramic composition of Claim 1, wherein the resistivity modifier comprises from about 25 vol.% to 30 vol.% of the base material.

9. The ESD dissipative ceramic composition of Claim 1, wherein the resistivity modifiers is selected from the group consisting of oxides, carbides, nitrides, oxycarbides, oxynitrides, and oxycarbonitrides.

10. The ESD dissipative ceramic composition of Claim 1, wherein the flexural strength is at least 600 MPa.

11. The ESD dissipative ceramic composition of Claim 1, wherein the flexural strength is at least 700 MPa.

12. The ESD dissipative ceramic composition of Claim 1, wherein the flexural strength is at least 800 MPa.

13. The ESD dissipative ceramic composition of Claim 1, wherein the flexural strength is at least 900 MPa.

14. The ESD dissipative ceramic composition of Claim 1, wherein the flexural strength is at least 1000 MPa.

15. An ESD dissipative component part made from a ceramic of Claim 1, where the component has less than 600 particles/cm<sup>2</sup> in the particle generation test and where the component has an Ra of less than 3000 Å.

16. The ESD dissipative component part of Claim 15, wherein the surface finish is produced by tumbling.

17. The ESD dissipative component part of Claim 15, wherein the color of the ceramic is light.

18. The ESD dissipative component part of Claim 15, wherein the color of the ceramic is dark.

19. An ESD dissipative ceramic composition formed by sintering a mixture comprising a base material and one or more resistivity modifiers for a sufficient time and at a sufficient temperature to achieve at least 99.5 percent of the theoretical density;

wherein the base material comprises a tetragonal zirconia polycrystal (TZP);

wherein the resistivity modifier comprises from about 5 vol.% to 60 vol.% of the base material and is selected from the group consisting of conductive and semiconductive materials or mixtures thereof;

and wherein the ESD dissipative ceramic composition has the following physical properties:

- (a) volume resistivity ranging from  $10^5$  -  $10^9$  Ohm-cm;
- (b) flexural strength of at least 500 MPa; and
- (c) voltage decay time of less than 500 ms.

20. The ESD dissipative ceramic composition of Claim 19, wherein the TZP comprises yttria stabilized TZP (Y-TZP) wherein the yttria is present at from about 2.5 to 4.5 mole percent.

21. The ESD dissipative ceramic composition of Claim 20, wherein the Y-TZP comprises 2.6 mole percent yttria.

22. The ESD dissipative ceramic composition of Claim 20, wherein the Y-TZP comprises 2.8 mole percent yttria.

23. The ESD dissipative ceramic composition of Claim 20, wherein the Y-TZP comprises 3 mole percent yttria.

24. The ESD dissipative ceramic composition of Claim 19, wherein the resistivity modifier comprises from about 10 vol.% to 50 vol.% of the base material.

25. The ESD dissipative ceramic composition of Claim 19, wherein the resistivity modifier comprises from about 20 vol.% to 40 vol.% of the base material.

26. The ESD dissipative ceramic composition of Claim 19, wherein the resistivity modifier comprises from about 25 vol.% to 30 vol.% of the base material.

27. The ESD dissipative ceramic composition of Claim 19, wherein the resistivity modifiers is selected from the group consisting of oxides, carbides, nitrides, oxycarbides, oxynitrides, and oxycarbonitrides.

28. The ESD dissipative ceramic composition of Claim 19, wherein the flexural strength is at least 600 MPa.

29. The ESD dissipative ceramic composition of Claim 19, wherein the flexural strength is at least 700 MPa.

30. The ESD dissipative ceramic composition of Claim 19, wherein the flexural strength is at least 800 MPa.

31. The ESD dissipative ceramic composition of Claim 19, wherein the flexural strength is at least 900 MPa.

32. The ESD dissipative ceramic composition of Claim 19, wherein the flexural strength is at least 1000 MPa.

33. An ESD dissipative component part made from a ceramic of Claim 19, where the component has less than 600 particles/cm<sup>2</sup> in the particle generation test and where the component has an Ra of less than 3000 Å.

34. The ESD dissipative component part of Claim 33, wherein the surface finish is produced by tumbling.

35. The ESD dissipative component part of Claim 33, wherein the color of the ceramic is light.

36. The ESD dissipative component part of Claim 33, wherein the color of the ceramic is dark.

37. An ESD dissipative ceramic composition comprising from about 85 to 60 vol.% Y-TZP and from about 15 to 40 vol.% ZnO densified to at least 95% of the theoretical density by sintering as the primary heat treatment.

38. The ESD dissipative ceramic composition of Claim 37, wherein a secondary heat treatment is employed to increase the theoretical density to greater than 99%.

39. The ESD dissipative ceramic composition of Claim 37, wherein the composition has an L\* color measurement of at least 50 using the CIE 1976 L\*a\*b\* scale on an XLE colorimeter.

40. An ESD dissipative ceramic composition comprising from about 90 to 50 vol.% Y-TZP and from about 10 to 50 vol.% semi-conductive SnO<sub>2</sub> densified to at least 95% of the theoretical density by sintering as the primary heat treatment.

41. The ESD dissipative ceramic composition of Claim 40, wherein the composition has an L\* color measurement of at least 50 using the CIE 1976 L\*a\*b\* scale on an LKE colorimeter.

42. An ESD dissipative ceramic composition comprising from about 80 to 70 vol.% Y-TZP and from about 20 to 30 vol.% LaMnO<sub>3</sub> densified to at least 95% of the theoretical density by sintering as the primary heat treatment.

43. An ESD dissipative ceramic composition comprising from about 90 to 60 vol.% Y-TZP and from about 10 to 40 vol.% LaCrO<sub>3</sub> densified to at least 99% of the theoretical density by sintering as the primary heat treatment, followed by hot isostatic pressing as the secondary heat treatment.

44. An ESD dissipative ceramic composition comprising from about 90 to 75 vol.% Y-TZP and from about 10 to 25 vol.% ZrC densified to at least 95% of the theoretical density by sintering as the primary heat treatment, followed by hot isostatic pressing as the secondary heat treatment.

45. An ESD dissipative ceramic composition comprising about 75 vol.% Y-TZP and about 25 vol.% BaO 6Fe<sub>2</sub>O<sub>3</sub> densified to at least 95% of the theoretical density by sintering as the primary heat treatment, followed by hot isostatic pressing as the secondary heat treatment.

46. An ESD dissipative ceramic composition comprising AlN heat treated in argon at 1900°C followed by rapid cooling to room temperature at a rate greater than 10°C/minute.

47. An ESD dissipative ceramic comprising ZrO<sub>2</sub> and semi-conductive SnO<sub>2</sub>, said ceramic having the following physical characteristics:

- (a) predetermined decay time;
- (b) hardness greater than 10GPa Vickers; and
- (c) a density of at least 99% of theoretical.

48. An ESD dissipative ceramic composition formed by sintering a mixture comprising a base material and one or more resistivity modifiers;

wherein the base material comprises a tetragonal zirconia polycrystal (TZP);

wherein the resistivity modifier comprises from about 5 vol.% to 60 vol.% of the base material and is selected from the group consisting of conductive and semiconductive materials or mixtures thereof;

and wherein the ESD dissipative ceramic composition has the following physical properties:

- (a) volume resistivity ranging from  $10^6$  -  $10^9$  Ohm-cm;
- (b) flexural strength of at least 400 MPa; and
- (c) voltage decay time of less than 500 ms.

49. The ESD dissipative ceramic of Claim 48, wherein the sintering is conducted in air.

50. The ESD dissipative ceramic of Claim 49, wherein a secondary heat treatment step comprises hot isostatic pressing.

51. An ESD dissipative ceramic comprising  $ZrO_2$  and semi-conductive  $SnO_2$ , said ceramic having the following physical characteristics:

- (a) predetermined decay time;
- (b) hardness greater than 10GPa Vickers; and
- (c) an  $L^*$  color measurement of at least 50 using the CIE 1976  $L^*a^*b^*$  scale on an LKE colorimeter.

52. The ESD dissipative ceramic of Claim 51, wherein the  $\text{SnO}_2$  is present in the range of 20-80% by vol of the initial reagents.

53. A method of processing ESD dissipative ceramics comprising the steps of:  
(a) consolidating two or more powders to a final density by one or more heat treatments, and

(b) using a final heat treatment to produce at least a 25% change in the resistivity of the resulting ceramic.

54. The process of Claim 53, wherein the final heat treatment is conducted in air at less than 90% of the sintering temperature.

55. The process of Claim 53, wherein the final heat treatment is conducted in oxygen at a partial pressure less than that of atmospheric oxygen.

56. The process of Claim 53, wherein the final heat treatment increases the resistance of the resulting ceramic.

57. The process of Claim 53, wherein the final heat treatment decreases the resistance of the resulting ceramic.

58. The process of Claim 53, wherein the final heat treatment moves volume resistivity into the range  $10^6$ - $10^9$  ohm-cm.

59. A method of forming light colored ESD dissipative ceramics comprising the steps of:

(a) forming a mixture comprising from about 85 to 60 vol.% Y-TZP and from about 15 to 40 vol.% ZnO; and

(b) densifying the mixture to at least 95% of the theoretical density by a primary heat treatment.



60. The method of Claim 59, further comprising employing a secondary heat treatment step to increase the theoretical density to greater than 99%.

61. A method of forming light colored ESD dissipative ceramics comprising the steps of:

(a) forming a mixture comprising from about 90 to 50 vol.% Y-TZP and from about 10 to 50 vol.% semi-conductive  $\text{SnO}_2$ ; and

(b) densifying the mixture to at least 95% of the theoretical density by a primary heat treatment.

62. The method of Claim 61, further comprising employing a secondary heat treatment step to increase the theoretical density to greater than 99%.

63. A method of modifying the resistivity of ESD dissipative ceramics comprising the step of hot isostatic pressing said ceramics under controlled conditions of heat and atmosphere.

64. A method of forming ceramic-based components for ESD-dissipative purposes comprising the steps of:

(a) forming an ESD dissipative ceramic composition;

(b) forming the desired surface finish on said ceramic composition; and

(c) forming ceramic-based components either in whole or in part, in which the ceramics produce less than 600 particles/cm<sup>2</sup> in the particle generation test for ESD-dissipative purposes.

65. The method of Claim 64, wherein the surface finish is formed by tumbling.

66. The method of Claim 64, wherein the entire component is formed from the

ESD dissipative ceramic composition.

67. The method of Claim 64, wherein only a portion of the component is formed from the ESD dissipative ceramic composition.

68. An ESD dissipative component, formed by the method of Claim 64, wherein the component is selected from the group consisting of MR (magnetoresistive) head substrates, transfer tools for magnetic head manufacturing, tools, fixtures, and containers for HGA (head gimbal assembly), HSA (head stack assembly), HDD (hard disk drive) assembly, tools, fixtures, and containers for wafer handling, processing, and cleaning, tools, fixtures, and containers for wire bonding, trimming, cutting, pick-and-place nozzles for IC chip handling, nozzles for adhesive and solder dispensing, wafer handling fixtures, end effectors, vacuum chucks, IC handling and test fixtures, tools, fixtures, and containers for ESD sensitive devices, assembly fixtures for IC's and magnetic heads, tweezers, screw drivers, scissors, blades, parts for robotic fingers, tools, fixtures, and containers for electro-optic coating process, tools, fixtures, and containers for reticles (photo mask).

69. A electrical sensing element formed at least in part from a zirconia-base structural ceramic having a strength of at least 400 MPa, said ceramic further comprising at least 10 vol%  $\text{ZrO}_2$ , wherein electrical conductivity of the ceramic is provided by an additive present as a non-zirconia phase.

70. The sensing element of Claim 69, adapted for or service at room temperature.

71. The sensing element of Claim 69 or 70, adapted for measuring temperature, force, or both temperature and force.

72. The sensing element of Claim 69 or 70, where the non-zirconia phase additive comprises  $\text{ZnO}$ .

73. The sensing element of Claim 69 or 70, where the conductivity of the ceramic is adjusted so that the sensing region(s) is only part of the whole.

74. The sensing element of Claim 69 or 70, where the responses from two or more sensing regions are detected independently.

75. A nonmagnetic ESD dissipative ceramic composition formed by sintering a mixture comprising a base material and one or more nonmagnetic resistivity modifiers; wherein the base material comprises a tetragonal zirconia polycrystal (TZP); wherein the resistivity modifier comprises from about 5 vol.% to 60 vol.% of the base material;

and wherein the ESD dissipative ceramic composition has the following physical properties:

- (a) volume resistivity ranging from  $10^6$  -  $10^9$  Ohm-cm;
- (b) flexural strength of at least 400 MPa; and
- (c) a residual flux density no greater than about 10 Gauss.

76. The nonmagnetic ESD dissipative ceramic composition of Claim 75, wherein the resistivity modifiers have a molar magnetic susceptibility of less than  $10^{-3}$  ml/mol.

77. The nonmagnetic ESD dissipative ceramic composition of Claim 76, wherein the resistivity modifiers are selected from the group consisting of ZnO, SnO<sub>2</sub>, ZrO<sub>2</sub>, Y<sub>2</sub>O<sub>3</sub>, Al<sub>2</sub>O<sub>3</sub>, ZrC, SiC, and mixtures thereof.